

APPENDIX AA

Evaluation of Alternative Desalination Plant Subsurface Intake Technologies

*Prepared by Water Globe Consulting, LLC,
March 2010*



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PROJECT: Seawater Desalination Project at Huntington Beach
PROJECT NO: 0007-2009-0001
SUBJECT: Evaluation of Alternative Desalination Plant Subsurface Intake Technologies
DATE: March 31, 2010

INTRODUCTION

The intent of this technical memorandum is to evaluate the feasibility of alternative subsurface and open ocean intakes for a 50 MGD seawater desalination project located in the City of Huntington Beach, California. This evaluation is based on a site-specific review of the hydrogeological and soil conditions in the vicinity of the desalination plant site and builds upon a critical review of prior intake studies completed for this project.

If the desalination facility was the sole user (“stand-alone” operation) of the HBGS’ intake and outfall water system it would require a flow rate of 152 MGD to meet the intake needs of the desalination project.

Overview of Plant Site Setting and Hydrogeological Conditions

The proposed seawater desalination project is located on a 13-acre site within the boundaries of the HBGS. The site is bordered by the city of Huntington Beach Maintenance yard on the north, the Orange County Flood Control District flood channel (Huntington Beach Channel) on the east, HBGS facilities on the south and an electrical switchyard to the west. The plant site is approximately 0.5 miles from the Pacific Ocean and the depth of groundwater is on average between 5 to 9 feet below the surface.

Source water collected from subsurface intakes constructed along the shore near the plant site would be a combination of seawater and water from the nearby Talbert Aquifer. This coastal aquifer extends from 15 to 180 feet below the ground surface and is interconnected with the ocean and the Huntington Beach Channel. According to a 1996 California Department of Water Resources report entitled “*Santa Ana Gap Salinity Barrier, Orange County*” (DWR Bulletin No. 147-1, December 1966), the dominating soil conditions of the Talbert Aquifer are clay and silt beds that are laterally extensive and are encountered at depths of 50 to 75 feet below ground surface (bgs) and extend to depths of 100 to 120 feet bgs. The base of the Talbert Aquifer occurs at a depth of approximately 190 feet bgs.

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A study of the hydrogeological conditions of the Talbert Aquifer completed by CDM in 2000 (*Development Information Memorandum #9A Barrier System Modeling/Design Criteria – 100 % Submittal*, Groundwater Replenishment System – Project Development Phase, June 2000), indicates that in the vicinity of the project site this aquifer has a range of transmissivity of between 17,500 and 23,400 sq ft/day and storativity of 4.6×10^{-4} under confined conditions. Under unconfined conditions along the shore the Talbert Aquifer storativity is estimated at 0.01 to 0.05. These aquifer characteristics limit the individual capacity of intake wells to 2.2 to 5 million gallons per day (MGD) and constrain the use of subsurface intakes for extraction of the source water volume required for this project (i.e. 152 MGD).

SUBSURFACE INTAKES

Feasibility Overview

The feasibility of using subsurface intakes (vertical wells, slant wells, horizontal wells, and infiltration galleries) was evaluated in detail during the City of Huntington Beach's environmental review of this project. The City's environmental review ultimately led to the 2005 certification of a Re-circulated Environmental Impact Report (REIR) that concluded that subsurface intakes were environmentally inferior to the use of the power plant's existing open water infrastructure.

Subsequent to the City's certification of the project's REIR, a comprehensive feasibility study of the use of subsurface intakes in the vicinity of the proposed desalination plant site was completed by PSOMAS in 2007 (Attachment1). This study was prepared for an intake capacity of 100 MGD (50 MGD desalination plant production capacity) and is reflective of the actual near-shore geology and the water quality of the coastal aquifer near the desalination project site. Peer-review of the PSOMAS feasibility study as a part of this work indicates that this feasibility study is technically sound and that the study results are consistent with other hydrogeological analyses of the same aquifer completed in the vicinity of the project site by others, and discussed in the introductory section of this technical memorandum.

The PSOMAS feasibility study clearly leads to the conclusion that well intakes are not viable for the site specific conditions of the Huntington Beach desalination project because of the limited production capacity of the existing subsurface geological formation (the Talbert Aquifer); because the intake well operation would drain the existing nearby coastal wetlands (Talbert March, Brookhurst Marsh, and the Magnolia Marsh); would cause a measurable land subsidence in the vicinity of the site which may damage key traffic arteries such as the Pacific Coast Highway (PCH); and because the source water collected from the coastal aquifer in the vicinity of the desalination plant using wells will have very poor water quality in terms of high pathogen and ammonia content, and of low concentration of dissolved oxygen.

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In addition, it was found that subsurface well intakes are likely to intercept contaminated groundwater from the nearby Ascon Landfill as well as treated wastewater from the Talbert Seawater Intrusion barrier, both of which are located within several miles of the desalination plant site. Collecting groundwater from a coastal aquifer that may be contaminated with a leachate from the Ascon Landfill may introduce carcinogenic hydrocarbons into the source water supply of the desalination plant and therefore it may create an elevated public health risk. Removing a portion of the injection water from the Talbert Barrier would impair the function of this barrier to protect against seawater intrusion. Moreover, the introduction of treated wastewater collected from the Talbert Barrier into the source water supply of the desalination plant is not compliant with the existing regulatory requirements of the California Department of Public Health due to potential public health impacts.

The sections below provide a detailed feasibility analysis of alternative subsurface intakes. This analysis is completed assuming the seawater desalination plant is operating at 152 MGD of intake source seawater (100 MGD for production of 50 MGD of fresh water and 52 MGD for dilution of desalination plant concentrate). The feasibility analysis assumes that the HBGS discharge outfall will be used for concentrate disposal.

Description of Alternative Subsurface Intakes

Vertical Intake Wells: Vertical intake wells consist of water collection systems that are drilled vertically into a coastal aquifer (see Figure 1).

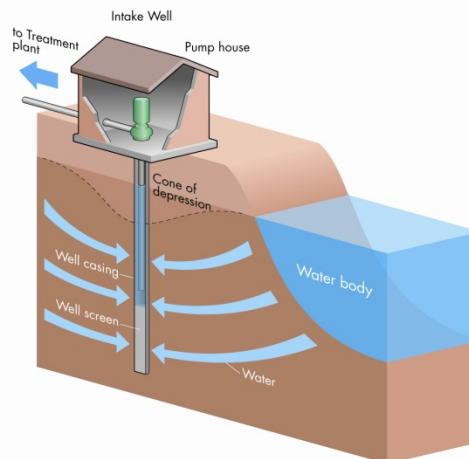


Figure 1 – Vertical Well

Each vertical well requires a service road, collector pipelines to move the water to the desalination facilities and a power supply. According to the 2007 feasibility study prepared by PSOMAS, a single unit well yield of 2.2 MGD (1,560 gpm) would be expected from a properly

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constructed, large diameter vertical production well for the site-specific conditions of the coastal aquifer near the Huntington Beach desalination plant site. PSOMAS' modeling results indicate that the total maximum production capacity of vertical wells placed under optimum conditions (i.e., a uniform aquifer structure with the same high-permeability soils throughout the aquifer) would be approximately 18.2 MGD (12,600 gpm). This is the maximum volume of ground water that can be extracted using this type of intake technology from this location. The information provided in the PSOMAS report indicates that the aquifer structure is far from optimum and therefore, the 2.2 MGD yield per well is a maximum theoretical value which cannot be exceeded. This limitation demonstrates that the use of vertical wells for source water collection is not viable for the site-specific conditions of this project due to the limited transmissivity of the coastal aquifer near the desalination plant site and the low unit yield capacity of the vertical wells. Therefore, vertical wells are technically infeasible because they cannot provide a sufficient amount of source water for stand-alone operations of the 152 MGD desalination plant.

To further illustrate the impracticality of vertical wells, one must create a hypothetical construct that assumes optimal hydrogeological conditions. Under this hypothetical construct, the implementation of this intake alternative would require installation of a very large number of wells (86) plus service roads, collector pipelines and a power supply for which beach property is not available. In order to deliver 152 MGD of source seawater for the project, 86 wells of a 2.2 MGD intake capacity each would have to be constructed. The 86 wells include a twenty five percent (25%) standby capacity, which is considered best management practice for vertical beach well engineering. As such, sixty nine (69) duty and seventeen (17) standby wells will need to be constructed assuming individual intake capacity of 2.2 MGD per well. Attachment 2 provides a detailed analysis of each type of alternative intake including vertical wells. As shown in Attachment 2, with 86 vertical wells located at a distance of 150 feet from each other (which is the distance needed to avoid influence on each well's performance/pumping capacity), the total distance is 2.4 miles of coastline ($86 \text{ wells} \times 150 \text{ ft} = 12,900 \text{ ft} / 5,280 \text{ ft} = 2.4 \text{ miles}$) to collect and transport the source water to the proposed desalination facility.

A desalination plant intake using vertical beach wells would take approximately 2 years for construction and the total cost of the implementation of such intake would be approximately \$379 million (see Attachment 2 for a detailed cost estimate). In summary, the use of vertical well intake is technically infeasible and unnecessarily costly.

As detailed by the PSOMAS report, the utilization of vertical beach wells is technically infeasible at this project site; nonetheless, it is also important to note that the construction and operation of a seawater desalination facility utilizing vertical beach wells would require greater energy consumption and produce increase in direct and indirect greenhouse gas emissions

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compared to a desalination facility utilizing the HBGS' existing seawater intake and outfall system.

Assuming an average intake well depth of 200 feet and use of high-efficiency vertical turbine pumps for conveyance of the water from the wells to the desalination plant, the power demand associated with intake well operation is 69 duty wells x 100 hp/well = 6,900 hp (5.15 MW). This energy use is over two-and-a-half times higher than the energy needed to convey the intake water from the ocean to the desalination plant intake (2 MW). This increase (3.15 MW) corresponds to total plant energy use increase of $(3.15 \times 1000 \times 24 / 50,000) \times 326 = 493$ kWh/AF of increase of the energy needed to produce desalinated water. Taking into consideration that the desalination facility's total energy use associated with the utilization of the HBGS' seawater intake system is approximately 31 MW, and that the energy penalty for using vertical wells is 3.15 MW, the operation of the vertical intake system will result in approximately a 10% increase in the total plant energy use and indirect carbon emissions. Furthermore, the 10% increase in energy consumption is a conservative estimate because of the energy use (and carbon emissions) associated with fresh water production is likely to further increase as a result of the operation of an aeration system that would likely be needed to address the low-oxygen content of the plant's discharge if subsurface wells are used.

Slant Wells. Slant wells are subsurface intake wells drilled at an angle and extending under the ocean floor to maximize the collection of seawater and the beneficial effect of the natural filtration of the collected water through the ocean floor sediments (See Figure 2).

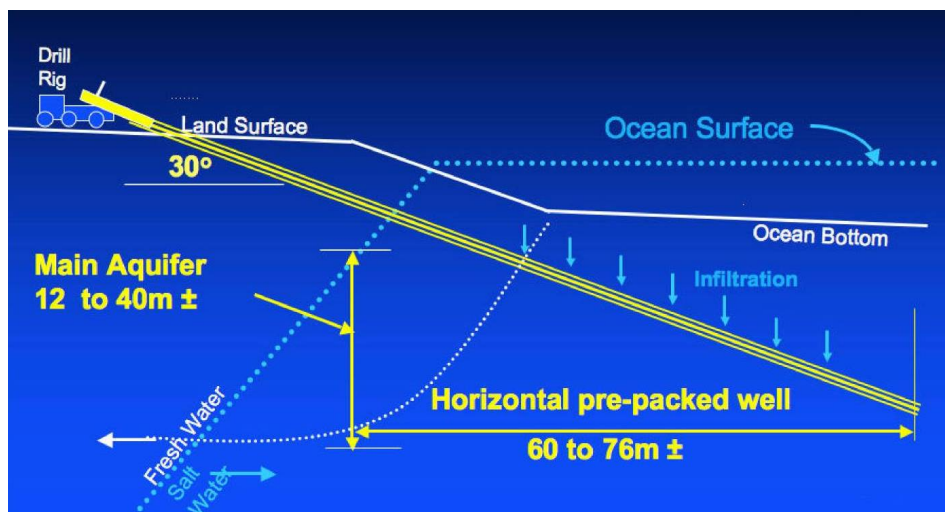


Figure 2 – Slant Well Intake

According to the 2007 PSOMAS feasibility study, collection of 152 MGD of seawater needed for this project would require the use of 35 slant intake wells of capacity of 4.3 MGD

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(3,000 gpm) each. These slant wells could be grouped in clusters of three. The distance between the well clusters would be 700 to 1,000 feet.

The total length of beach occupied by slant wells, service roads, collector pipelines and an electrical supply would be approximately 4.6 miles (35 slant wells located at a distance of 700 feet from each other, (which is the distance needed to avoid influence on each well's performance/pumping capacity), the total distance is 35 wells x 700 ft = 24,500 ft /5,280 ft = 4.64 miles) and the construction costs for implementation of this alternative would exceed \$211 million. See Attachment 2 for a detailed cost estimate and assessment of the length of the impacted coastal area.

The required construction time for the 35 slant wells will be comparable to that of the construction of vertical wells (i.e., approximately two years) despite the fewer number of wells because the slant well structure is more complex. Based on experience at Dana Point, the construction and commissioning of a single well will take 6 to 8 weeks. Energy for conveyance of the water collected from the slant wells to the desalination plant site is projected to be similar to that for conveyance of source water collected by vertical intake wells.

While the use of slant wells would allow the source water flow collection of 152 MGD, needed for production of 50 MGD of drinking water, based on the site-specific feasibility analysis completed by PSOMAS the long-term use of slant wells is expected to result in a number of negative environmental impacts and human health risks:

1. Detrimental environmental impact of intake well operations on the adjacent Talbert Marsh;
2. Poor water quality of the Talbert Aquifer in terms of ammonia, bacterial contamination and lack of oxygen;
3. Interception of contaminated groundwater from nearby Ascon Landfill which may introduce carcinogenic hydrocarbons in the source water supply of the desalination plant;
4. Interception of injection water from the Talbert Barrier by the intake and impairment of the function of this barrier to protect against seawater intrusion;
5. Subsidence of public roads and structures due to drawdown of the groundwater table;
6. Impairment of the aesthetic value of the coastal shore by the obtrusive above-ground intake structures and service roads, collector pipelines, electrical supplies and related infrastructure.

The site-specific concerns 1 through 5 listed above are largely independent of the size of the intake, and therefore of the size of the proposed project. Therefore, the reduction of the size of the intake/production capacity of the desalination facility will not improve their viability. Any one of the site-specific conditions 1 through 5 would render subsurface intakes more impactful to

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the environment than the project because it will result in either irreversible damage to the Talbert Marsh and negate years of restoration measures, or because the source water collected with a subsurface well may be of impaired source water quality.

Draining & Damage of Talbert Marsh and Other Coastal Wetlands

Operation of the slant wells at a total capacity of 100 MGD or greater (the proposed plant's intake requirement is 152 MGD) will cause the water level in the vicinity of the wells to drop from 5 feet to 60 feet below ground surface and the water table in 4,000 feet wide zone (strip) located parallel to the shore and perpendicular to the well field line.

Wetlands (including the Brookhurst, Magnolia, Newland and Talbert Marshes) are present in the immediate vicinity of the intake of the Huntington Beach site, and these marshes are hydraulically connected to the aquifer from which the slant wells will collect water for the desalination plant. Therefore, the extraction of water by the slant wells would result in a drawdown of the level of water in the Talbert Marsh and other adjacent wetlands which in turn will impact negatively wetlands' natural flora and fauna. The Talbert, Brookhurst and Magnolia Marshes are well known for its fragile environment and currently are undergoing a multi-million dollar, multi-year restoration effort. Therefore, the adverse environmental impact of operating subsurface intake in the vicinity of the Talbert, Brookhurst and Magnolia marshes is sufficient reasons to render this type of intake infeasible.

Source Water Quality Unsuitable for Production of Drinking Water

The water that would be collected via any type of subsurface intake will likely be unsuitable as a source for direct drinking water because (1) it contains an unacceptably high content of pathogens and ammonia (see Attachment 3) which present threat to human health; (2) it has a very low level of dissolved oxygen, (DO is less than 0.1 mg/L), which would have a harmful effect on the environment when a low-DO concentrate is discharged to the ocean. In addition the DO of the drinking water will also be unacceptably low.

Per the analysis found in the 2007 PSOMAS report, due to the close proximity of the subsurface intake to the Ascon Landfill, it is likely that coastal aquifer drawdown by the subsurface intake to supply the desalination facility could immobilize hazardous materials contained in the landfill, thereby rendering it unsuitable for public water supply. Since the entire subsurface aquifer in the vicinity of the intake maybe an impaired water quality source, the reduction of the intake flow/project size will not resolve this concern.

Negative Impact of the Talbert Barrier Protecting Against Salt Intrusion

In order to protect inland groundwater quality from seawater intrusion along the coast, a fresh water barrier must be maintained. A barrier is a man-made protective curtain generated by injecting large volumes of freshwater or highly treated wastewater into the ground in order to

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block the movement of the seawater into the fresh water aquifer. Since the slant well intake is relatively close to the underground barrier of fresh/treated wastewater (which will be supplied by the Groundwater Replenishment Project¹) installed in the vicinity of the project to protect saltwater intrusion, referred to as Talbert Barrier, taking away some fresh water from the barrier, may: (1) reduce the protective effectiveness of the barrier against seawater intrusion in the groundwater basin, and (2) may introduce treated wastewater into the source water used for the desalination facility. Since the negative impact of the intake could be permanent, even if the amount of flow is reduced (i.e., project size is diminished), these adverse impacts would continue to occur even if the project size is reduced.

Subsidence and Potential Damage of Roads and Other Infrastructure

The 2007 PSOMAS report further concludes that a permanent reduction of the underground water table in the area of the project site, combined with the weak bearing capacity and high liquefaction potential of the soils in this area, may result in subsidence (sink hole or dip) under the infrastructure along the coast, which in turn would jeopardize traffic safety and temporarily limit the public use of the beach of the City of Huntington Beach. Reduction of the intake size will reduce the period over which the subsidence will occur but will not eliminate the subsidence effect all together. Therefore, slant well subsurface intakes may damage the public beach access roads, the PCH, beach structures and utilities and the structural integrity of the HBGS.

Due to the unfavorable site-specific soil and hydrogeological conditions; existing coastal aquifer contamination, and the fact that the environmentally-fragile coastal wetlands located adjacent to the desalination plant slant intake could be drained as a result of intake operations, the use of slant wells is not viable for the Huntington Beach seawater desalination project. In summary, the use of slant well intake alternative is environmentally and technically infeasible, and cost prohibitive.

Energy for conveyance of the water collected from the slant wells to the desalination plant site is projected to be similar to that for conveyance of source water collected by vertical intake wells.

Horizontal Wells. Horizontal wells are subsurface intakes which have a number of horizontal collection arms that extend into the coastal aquifer from a central collection caisson in which the source water is collected (see Figure 3). The water is pumped from the caisson to the desalination plant intake pump station, which in turn conveys it into the desalination plant

¹ The Groundwater Replenishment System (GWRS) Project produces highly treated recycled wastewater and replenish the groundwater for urban, agricultural and industrial uses. In addition, the GWRS's highly treated recycled wastewater is used to inject into the Talbert Barrier to protect the underground drinking water aquifer from seawater intrusion.

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pretreatment system. Similar to slant wells, horizontal wells would allow for the collection of more water per well and deliver the total flow of 152 MGD needed for operation of 50 MGD seawater desalination plant. Even if ideal hydro-geological conditions for this type of wells are assumed to exist (i.e., each well could collect a maximum 5 MGD of source water), horizontal well intake construction would include the installation of a total of 38 wells (30 duty wells and 8 (25%) standby wells). The 25% standby capacity is considered best management practices for the engineering of horizontal beach wells. The total length of coastal seashore impacted by this type of well intake would be 2.8 miles. As shown in Attachment 2, with 38 slant wells located at a distance of 400 feet from each other, (which distance is needed to avoid influence on each-other's performance/pumping capacity), the total distance is $38 \text{ wells} \times 400 \text{ ft} = 15,200 \text{ ft} / 5,280 \text{ ft} = 2.8 \text{ miles}$.

Since the horizontal wells would collect source water from the same coastal aquifer as the slant wells, they would face the same environmental and technical problems: irreversible detrimental environmental impact on the adjacent coastal wetlands; interception of contaminated groundwater from the nearby Ascon Landfill and injection water from the Talbert seawater intrusion barrier; subsidence of public roads and structures due to drawdown of the groundwater table, and; increased public health risk due to the low quality of the coastal aquifer water in terms of pathogen and ammonia contamination.

As a result, the horizontal intake system is not the environmentally preferred alternative. The cost for construction of horizontal well intake system for collection of 152 MGD of seawater needed for the desalination plant operation is estimated at \$223 million (see Attachment 2).

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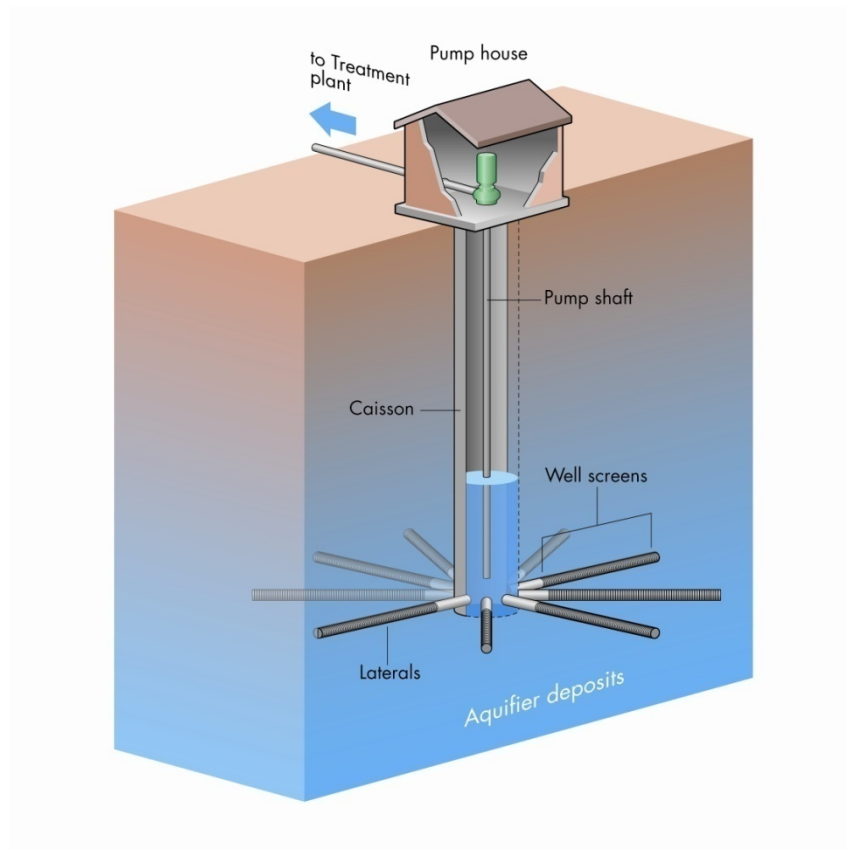


Figure 3 – Horizontal Intake Well

In summary, the horizontal intake alternative is not the environmentally preferred alternative, and is technically infeasible and cost prohibitive.

The time needed for construction horizontal well intake is comparable to that of the construction of vertical and slant well intake. Energy for conveyance of the water collected from the slant wells to the desalination plant site is projected also to be similar to that for conveyance of source water collected by vertical and slant intake wells.

Subsurface Infiltration Gallery (Long Beach/Fukuoka Type Intake). The subsurface infiltration gallery intake system (also known as under-ocean floor seawater intake or seabed infiltration system) consists of a series of man-made submerged slow sand media filtration beds located at the bottom of the ocean in the near-shore surf zone, which are connected to a series of intake wells located on the shore. As such, seabed filter beds are sized and configured using the same design criteria as slow sand filters. The design surface loading rate of the filter media is typically between 0.05 to 0.10 gpm/sq ft. Approximately one inch of sand is typically removed from the surface of the filter bed every one to three years depending on the rate of deposit of residuals on the surface of the filter bed. As it can be seen on Figures 4 and 5, the ocean floor

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has to be excavated in order to install the intake piping of the wells and pipes are buried at the bottom of the ocean floor.

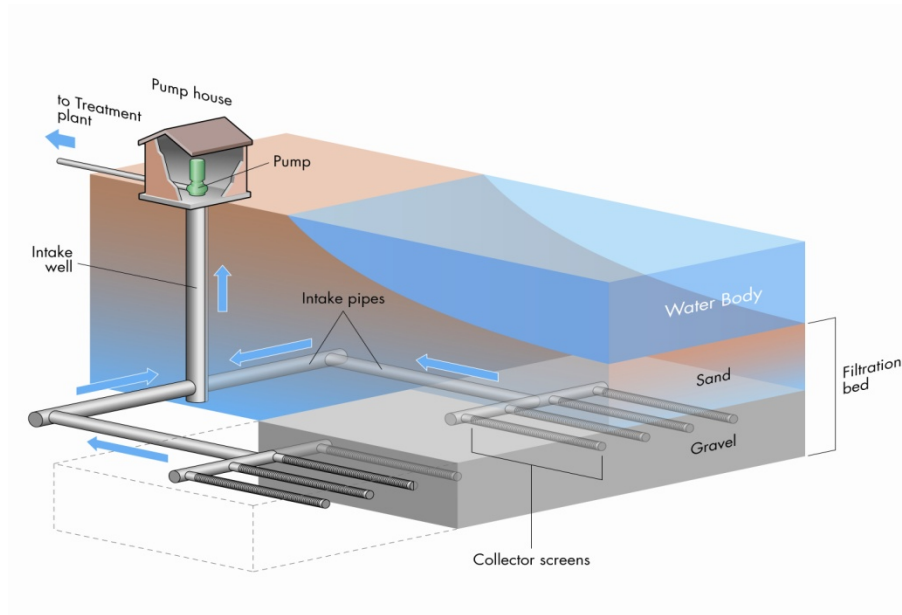


Figure 4 – Subsurface Infiltration Gallery (Fukuoka Type Intake)

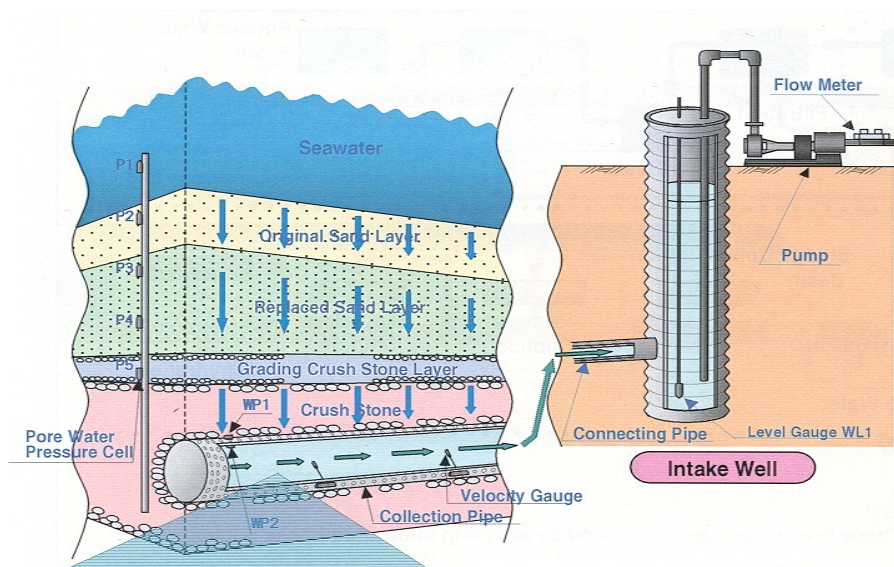


Figure 5 – A Cross-Section of Subsurface Infiltration Gallery

The construction of an infiltration gallery sized to provide 152 MGD of seawater would impact approximately 75 acres of seafloor. This system would consist of thirty nine (39) intake

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filtration bed cells and thirty nine (39) 48-inch diameter connector pipelines spaced at 210 foot intervals. The intake filtration bed would be 8,200 feet (1.5 miles) in length and 200 ft wide and 6 feet deep and would disturb about 37.5 acres of seafloor. An additional 37.5 acres of seafloor would also need to be excavated to a depth of 6 feet to lay the 39 connector pipes from the shore through the surf zone to the filter bed. The design criterion used for estimating of the area of the infiltration gallery is conservative and therefore, no additional standby intake filtration bed cells are incorporated in this design.

The 39 collector pipelines would be connected to 39 wells located on the beach and would need to be connected to an electrical supply and service roads for regular maintenance. The wells would pump the seawater to the desalination facility via a newly constructed pipeline (one mile long, ranging from 24 to 72 inches in diameter). Each of the 39 wells would require approximately 2,800 square feet of beachfront property, for a combined loss of over 2.5 acres of beachfront property and related impact to public access. The collection pipeline would require an easement over 1.5 additional acre of shoreline. The combined impact to benthic habitat and public access associated with the submerged seabed intake gallery is approximately 79 acres.

The construction of a Long Beach/Fukuoka-type subsurface intake would have many other significant environmental impacts in addition to the irreversible destruction/loss of 79 acres of marine and coastal habitat. Some of the key impacts are as follows:

- Excavation and construction of 39 intake water collection wells and trenches for collector piping along a one-mile strip of the shoreline would limit public access to the beach, which would result in a significant impact on the beneficial use of the Huntington Beach shoreline by the public and will cause measurable loss of local tax revenue and income to visitor serving businesses in Huntington Beach.
- The need to dewater and dispose over 363,000 cubic yards of ocean bottom sediments (37.5 acres of seafloor x 43,560 sq ft/acre x 6 feet of depth)/27 cu ft/yard = 363,000 cu yards) to a sanitary landfill or ocean disposal site makes the use of such intake impractical because there are no available landfills in the vicinity of Huntington Beach which can accept such a large volume of solids waste over such a short period of time and ocean disposal may have regulatory restrictions.
- Taking under consideration that one large truck load is 14 cubic yards, the removal and transportation of 363,000 cubic yards of ocean bottom sediments will require over 26,000 truck loads (52,000 one-way truck trips). It should be noted that since the native bottom sediments of the excavated ocean floor will need to be replaced with filtration sand that will need to be delivered on site, the amount of construction truck trips and associated

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traffic congestion will double. The total amount of truck traffic associated with the construction of the infiltration gallery will be over 20 times higher than the truck traffic associated with the construction of the desalination plant and the product water delivery pipeline.

- Because of the order-of-magnitude increase in traffic load due to the construction of the infiltration gallery, the total direct greenhouse gas (GHG) emissions associated with project construction will also increase by an estimated 100,000 metric tons of CO₂-based on the calculations found in the Energy Minimization and Greenhouse Gas Reduction Plan prepared for the Huntington Beach Desalination Project. This increased level of GHG emissions from construction will continue for over 2-year period.
- Infiltration galleries will have significantly larger environmental impact as compared to vertical, horizontal and slant wells because of the significantly larger soil excavation volume associated with construction of infiltration gallery and the destruction of the benthic flora and fauna over the entire intake footprint.
- The construction of the infiltration gallery could be completed within the time-frame of the construction of the desalination plant (i.e., 2 years). However, this would only be possible with multiple crews completing simultaneous excavation and construction along the entire 1.5 mile length of the intake footprint. Because of the significantly higher construction intensity and labor needs, the traffic and other construction impacts associated with the construction of infiltration gallery will exceed these of any other type surface or subsurface intake.
- As indicated previously, the energy consumption and related direct GHG emissions associated with the construction of an infiltration gallery will far exceed that associated with the implementation of other intake alternatives. Additionally, once in operation, the energy associated with conveyance of source seawater from the infiltration gallery to the desalination plant will be comparable to that of the other subsurface intakes and will be approximately 2.5 times higher than that for collecting intake water from the HBGS' existing seawater intake system.
- In order to secure consistent operation of the infiltration galleries, the filter beds would need to be dredged every one to three years in order to remove the sediment and entrained marine life that would accumulate in the intake filter bed and over time will plug the bed. If this material is not removed, then the intake flow would decrease over

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time and the desalination plant would cease to function. The dredged material would need to be disposed away from the intake filter beds in order to prevent the removed solids from returning to the area of the infiltration gallery. This would not only result in a frequent destruction of the marine flora and fauna in the area but would also render the area unavailable for recreational activities during maintenance activities. A significant reduction (over 2 times) of infiltration capacity of an un-dredged filter bed over a period of six months was observed at the Long Beach infiltration gallery test facility and reported by Mr. Jason Allen from the Long Beach Water Department at the American Water Works Association's 2009 Annual Conference & Exposition in San Diego in June 2009 (see Attachment 4). As shown on page 18 of Attachment 4, between the period of June 08 to April 09, the intake flow collected by the infiltration system was steadily reduced from 200 to 350 gpm (avg. 275 gpm) down to 50 to 200 gpm (avg. 125 gpm), which is over a 2 fold reduction (see "green line" on the graph). The water quality results from the Long Beach infiltration gallery test also show that the water quality collected by the infiltration gallery is not adequate to be directly used for reverse osmosis (RO) desalination because of the very high level of turbidity (2.58 NTU vs. RO feed water quality requirement of 0.1 NTU or less) and high content of silt (Silt Density Index of 6.67 vs. RO feed water quality requirement of 4 or less). Water quality data from the infiltration gallery test are shown on page 17 of the Long Beach Water Department presentation (see Attachment 4, page 17; column "demo raw"). These results indicate that a full-scale desalination plant using an infiltration gallery as an intake will have to incorporate a pretreatment system to reduce turbidity and silt in the source seawater collected by the infiltration gallery down to levels suitable for RO desalination. In fact, the full-scale Fukuoka seawater desalination plant which also uses an infiltration gallery has an ultrafiltration pretreatment system ahead of the RO system to handle high level of turbidity and silt in the source water collected by this intake.

The total cost for construction of the submerged seabed infiltration gallery for a 152 MGD intake for the Huntington Beach seawater desalination plant is estimated at \$308 million (See Attachment 2). The additional cost associated with this type of intake system would effectively double the construction cost of the proposed Project. This, in turn, would impose a significant burden on the purchasers of water with no measurable environmental benefits.

It should be noted that the existing Fukuoka intake, which has a capacity of 13.2 MGD, is the largest operational submerged seabed infiltration gallery in the world. In order to produce the 152 MGD of sea water that would be required by the Huntington Beach Desalination Facility using a Fukuoka subsurface intake, Poseidon and its public agency partners would be required to bear the uncertainty of an 11 to 12-fold scale up in this technology, a large-scale project design that has never been implemented anywhere in the world. Experience throughout the world with

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the attempted utilization of beach wells and subsurface seabed infiltration gallery intake systems for larger desalination plants reveals potential technological flaws. The 17 MGD San Pedro del Pinatar seawater desalination plant, which utilized horizontal directionally drilled wells, experienced significant “technical issues and limitations” causing the plant’s operators to switch to an open water intake system for the plant’s phase two expansion.¹ The basic purpose of the Project is to utilize proven technology to provide a reliable supply of water with minimal environmental impacts and at an affordable price. The results from the testing of this experimental system by the Long Beach Water Department to date confirms that the performance risks associated with the use of this subsurface intake system are high (as indicated previously, system production capacity decreased over two times for a period of 6 months) and construction of such system at the large scale needed for the Huntington Beach project is not environmentally preferable, technically prudent and warranted or financially viable.

In summary, the overall impacts to the environment, the public coastal resources access/use associated with the construction and operation of an infiltration gallery would be significantly higher than the impacts for the proposed use of the existing intake for the Huntington Beach Desalination Project.

Summary Evaluation of Subsurface Intake Feasibility

The site-specific hydrogeological studies and engineering analysis used to evaluate the feasibility of use of alternative subsurface intakes for this project demonstrate that the alternative intakes that vertical wells, slant (Dana Point-type) wells, horizontal wells and subsurface infiltration galleries (Long Beach/Fukuoka type) and are not viable for the Huntington Beach project because of their significant environmental impacts, negative long-term influence on the beneficial use of coastal resources along the Huntington Beach shoreline, excessive construction-related traffic and GHG emissions, and elevated public health risks due to the poor water quality of the coastal aquifer and the potential influence of nearby Ascon Landfill and Talbert Gap Seawater Intrusion Protection Barrier. Additionally, the alternative subsurface intake systems were determined not to be the environmentally preferred alternative.

State regulatory restrictions are also a consideration when analyzing the feasibility of alternative seawater intakes. Notably, the Coastal Commission determined that for Carlsbad desalination project, the only large-scale seawater desalination plant permitted in the state of California to date, that there are no feasible or less environmentally damaging alternatives to using a power plant’s existing intake system. In the case of the Carlsbad plant, with respect to the same proposed seawater intake alternatives, the Commission found that “...*slant wells are infeasible because the water quality available from such intakes would make it difficult, if not impossible, to treat for desalination purposes, and that the construction impacts associated with*

¹ California Coastal Commission CDP application E-06-013 November 15, 2007, hearing transcript pages 170-171.

TECHNICAL MEMORANDUM

March 31, 2010

Page 16

this alternative render it environmentally inferior to the proposed project.... an infiltration gallery is environmentally inferior to the proposed project because this alternative would disrupt public access to marine resources, require frequent dredging, and would require the destruction of 150 acres of coastal habitat, and that the alternative is economically infeasible ...an offshore intake system would result in greater environmental impacts and that construction of an offshore intake would render the project economically infeasible.”¹

¹ Page 7 of 133 of the Approved Findings for the Carlsbad Desalination Project (W4a-8-2008)

152 MDG Intake Cost Estimates - February 2010

VERTICAL BEACH WELLS

Total Capacity =	152 MGD	
Individual Intake Well Capacity =	2.2 MGD	(Psomas, 2007)
Duty Number of Intake Wells Needed =	69	
Additional Standby Intakes Needed @ 25 % =	17	
Total Intake Wells Needed =	86	
Minimum Distance Between Wells (Best Case)=	150 ft	
Length of Beach Occupied by Wells =	2.4 miles	
Land Needed to Install Wells & Support Facilities	14.9 acres	
Cost of Installation of Individual Well =	\$ 1,900,000 per well	
Total Costs of Well Installation =	\$ 164,090,909	
Cost of Seawater Conveyance Pipelines @US\$525/ft =	\$ 6,722,386	
Cost of Intake Booster Pump Stations - =	\$ 31,900,000	
Cost of Electrical Power Supply for Well Pumps =	\$ 29,398,636	
Total Construction (Direct) Costs =	\$ 232,111,932	
Indirect Costs		
Acquisition of Land to Install Wells & Support Struct. =	\$ 7,434,886	
Engineering, Design and Procurement @ 25 % =	\$ 58,027,983	
Environmental Mitigation Costs @ 15 % =	\$ 34,816,790	
Contingency @ 20 % =	\$ 46,422,386	
TOTAL INDIRECT COSTS	\$ 146,702,045.14	
TOTAL PROJECT EPC COSTS =	\$ 378,813,977	

SLANT WELLS - Similar to Dana Point Desal Plant

Total Capacity =	152 MGD	
Individual Intake Well Capacity =	4.3 MGD	(Psomas, 2007)
Duty Number of Intake Wells Needed =	35	
Additional Standby Intakes Needed @ 25 % =	0	(Psomas, 2007)
Total Intake Wells Needed =	35	
Minimum Distance Between Wells (Best Case)=	700 ft	
Length of Beach Occupied by Wells =	4.6 miles	
Land Needed to Install Wells & Support Facilities	8.1 acres	
Cost of Installation of Individual Well =	\$ 2,500,000	per well
Total Costs of Well Installation =	\$ 88,372,093	
Cost of Seawater Conveyance Pipelines @US\$525/ft =	\$ 12,623,198	
Cost of Intake Booster Pump Stations - =	\$ 13,200,000	
Cost of Electrical Power Supply for Well Pumps =	\$ 15,235,814	
Total Construction (Direct) Costs =	\$ 129,431,105	
Indirect Costs		
Acquisition of Land to Install Wells & Support Struct. =	\$ 4,057,488	
Engineering, Design and Procurement @ 25 % =	\$ 32,357,776	
Environmental Mitigation Costs @ 15 % =	\$ 19,414,666	
Contingency @ 20 % =	\$ 25,886,221	
TOTAL INDIRECT COSTS	\$ 81,716,151	
TOTAL PROJECT EPC COSTS =	\$ 211,147,256	

HORIZONTAL RANNEY WELLS

Total Capacity =	152 MGD
Individual Intake Well Capacity =	5 MGD
Duty Number of Intake Wells Needed =	30
Additional Standby Intakes Needed @ 25 % =	8
Total Intake Wells Needed =	38
Minimum Distance Between Wells (Best Case)=	400 ft
Length of Beach Occupied by Wells =	2.8 miles
Land Needed to Install Wells & Support Facilities	8.7 acres
Cost of Installation of Individual Well =	\$ 2,600,000 per well
Total Costs of Well Installation =	\$ 98,800,000
Cost of Seawater Conveyance Pipelines @US\$525/ft =	\$ 7,770,000
Cost of Intake Booster Pump Stations - =	\$ 13,300,000
Cost of Electrical Power Supply for Well Pumps =	\$ 16,815,000
Total Construction (Direct) Costs =	\$ 136,685,000
Indirect Costs	
Acquisition of Land to Install Wells & Support Struct. =	\$ 4,361,800
Engineering, Design and Procurement @ 25 % =	\$ 34,171,250
Environmental Mitigation Costs @ 15 % =	\$ 20,502,750
Contingency @ 20 % =	\$ 27,337,000
TOTAL INDIRECT COSTS	\$ 86,372,800
TOTAL PROJECT EPC COSTS =	\$ 223,057,800

SUBSURFACE INFILTRATION GALLERY (LONG BEACH/FUKUOKA TYPE INTAKE)

Total Capacity =	152 MGD
Capacity of Individual Intake Filter Seabed Cells =	3.85 MGD
Duty Intake Gallery Cells Needed =	39
Additional Standby Intakes Needed @ 0 % =	0
Total Intake Gallery Cells Needed =	39
Length x Width x Depth Each Intake Filter Cell =	200x210x6 ft
Total Length of Intake System =	8190 ft
Land Needed to Install Wells & Support Facilities	79.0 acres
Cost of Installation of Individual Gallery =	\$ 3,820,000 per 3.85 MGD gallery
Total Costs of Gallery Installation =	\$ 150,815,584
Cost of Seawater Conv. Pipelines @US\$525/ft =	\$ 4,299,750
Cost of Intake Booster Pump Stations - =	\$ 5,320,000
Cost of Electrical Power Supply for Well Pumps =	\$ 7,806,779
Total Construction (Direct) Costs =	\$ 168,242,114
Indirect Costs	
Acquisition of Land to Install Intake & Support Struct. =	\$ 39,500,000
Engineering, Design and Procurement @ 25 % =	\$ 42,060,528
Environmental Mitigation Costs @ 15 % =	\$ 25,236,317
Contingency @ 20 % =	\$ 33,648,423
TOTAL INDIRECT COSTS	\$ 140,445,268
TOTAL PROJECT EPC COSTS =	\$ 308,687,382

**American Water Works Association
2009 Annual Conference & Exposition**

***Update for the Pilot and
Demonstration-Scale Research
Evaluation of Under-Ocean Floor
Seawater Intake and Discharge***

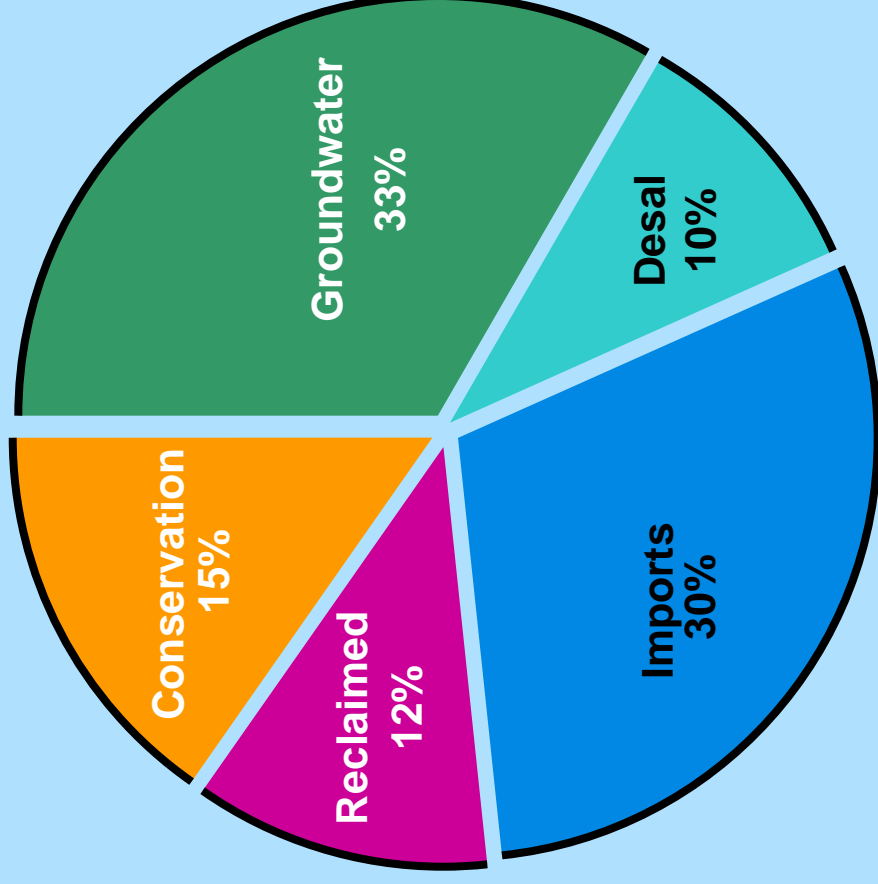
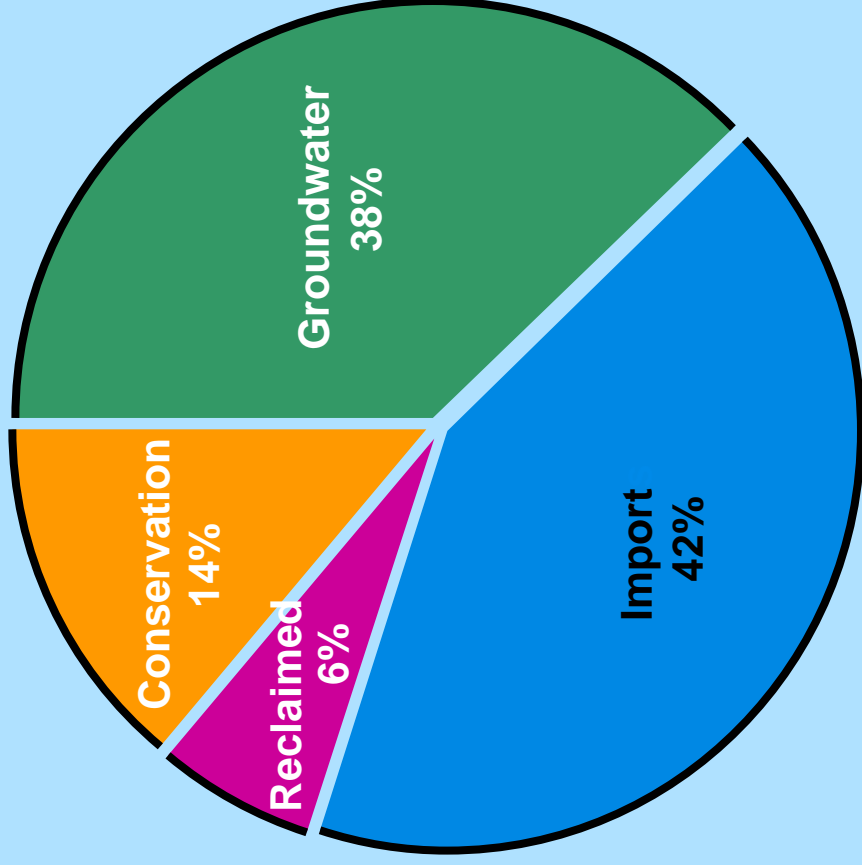
**Jason B. Allen, Robert C. Cheng, Tai J. Tseng, and Kevin L. Wattier
Long Beach Water Department**

June 16, 2009

LBWD's Resource Mix

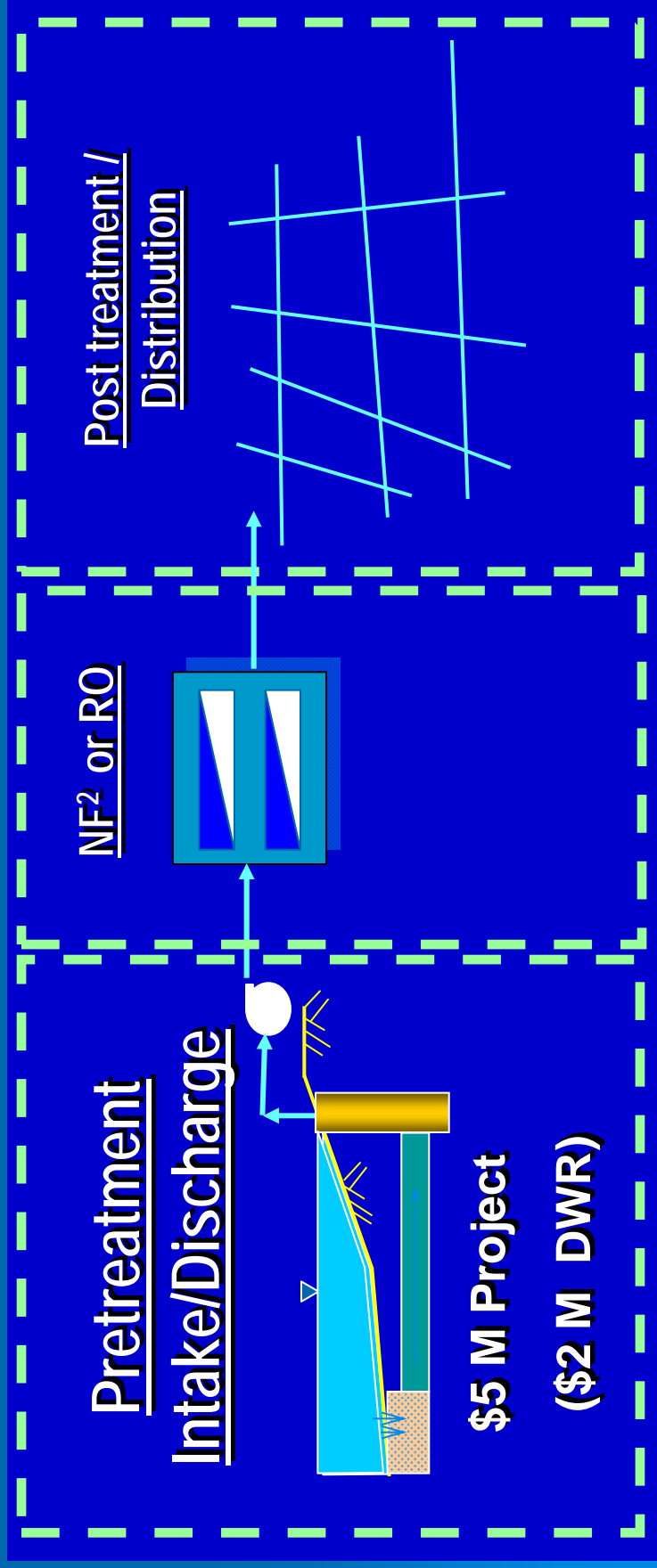
2009

2015



LBWD's Seawater Desalination Program

- A \$20 M, 10-year investment
- Leverage various partnerships for technical input and other support
- Federal / State / Local Funding



Problem?

Why Do We Need To Look At Intakes And Discharge Systems?

- Impingement/entrainment
 - Federal Clean Water Act, Section 316 (b)
- Brine dispersion

Research Objective

Types of Intake Systems

- Open Ocean Intakes
- Intakes W/Horizontal Directional Drilling
- Indirect Intake Beach Well
- Seabed Filtration Using Buried Pipes (LBWD Approach)

Research Objective

Fukuoka, Japan

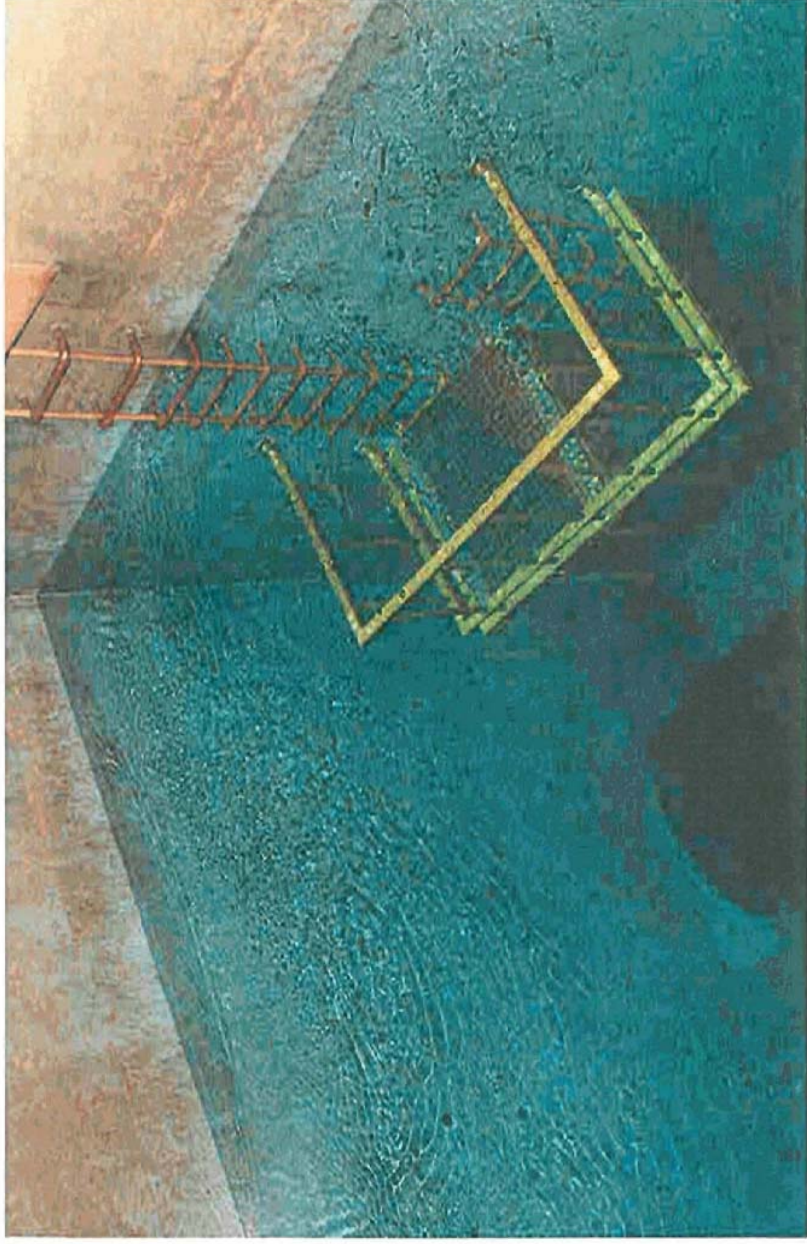


Images of Infiltration Intake



Research Objective

Fukuoka, Japan Infiltration Seawater Tank



Research Objective

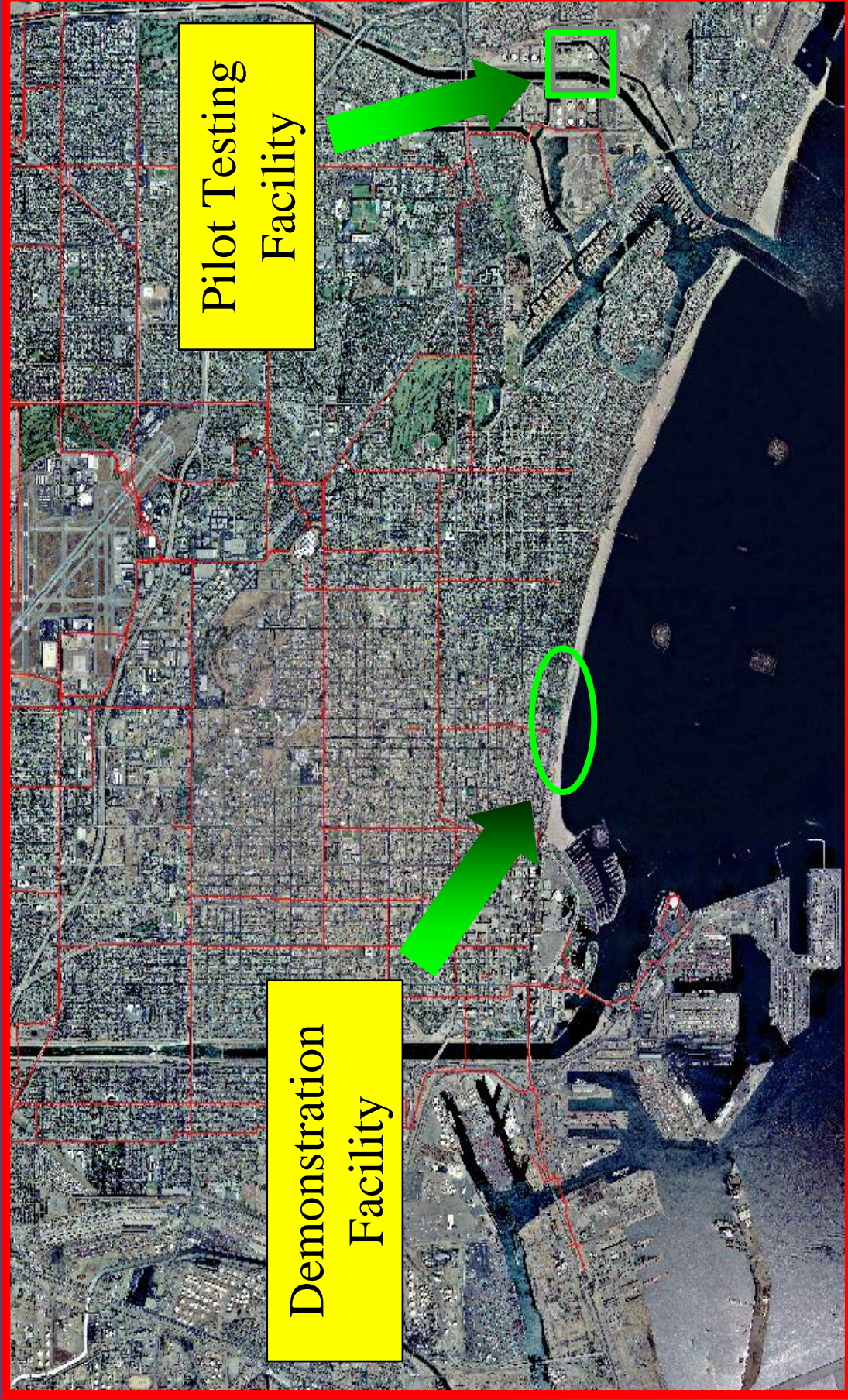
Project Overview

- Determine the maximum sustainable intake filtration and discharge rate
- Evaluate seasonal water quality impacts on the quantity and quality and determine if further treatment is needed (i.e. microfiltration)

LBWD's Research Approach

- Pilot Testing (2008)
- Demonstration Scale (2008 - 2010)
- Production Plant (~2015)

Current Research Sites



Pilot Testing – Columns

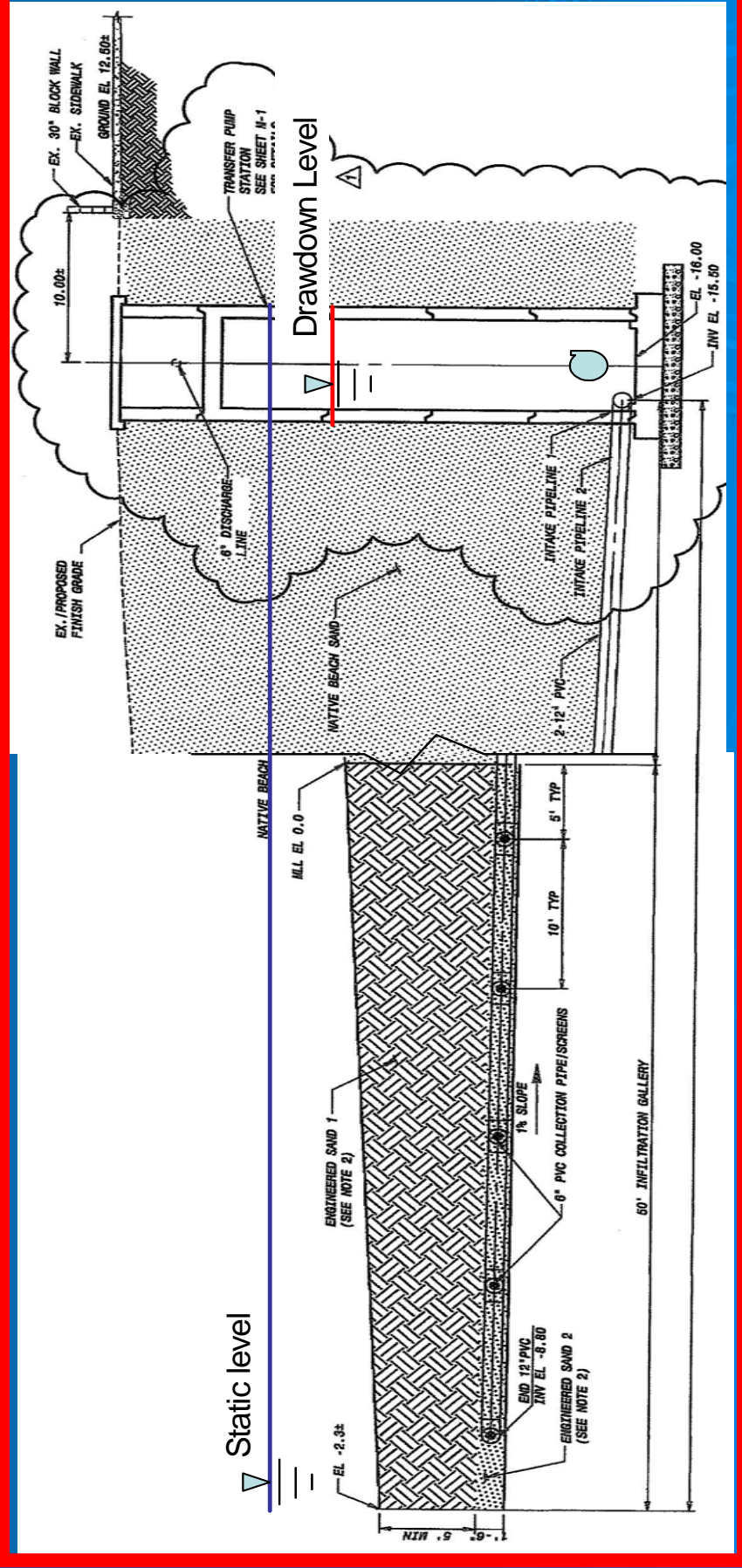
- Pilot-scale testing used 8-inch (in) columns
- Results previously presented (Allen, 2008)



Demonstration Facility-Layout



Cross Section Intake/Discharge



Construction



View at Low Tide



System Layout



**Underocean
Floor
(Demo Raw)**



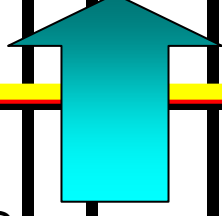
**Wet-well
(Filter Effluent)**



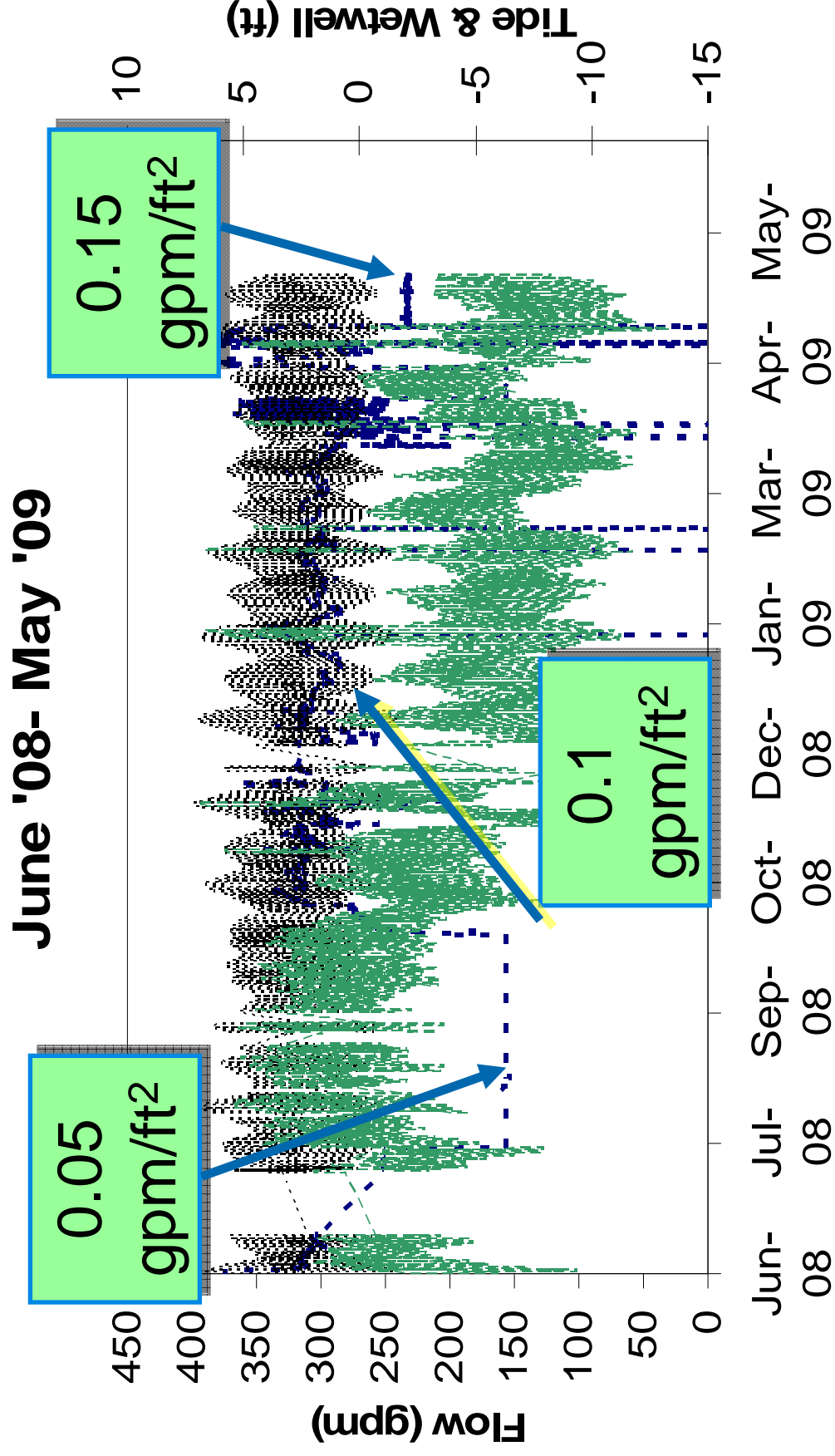
**Cartridge
Filtration
(Filter
Effluent +5)**

Demonstration WQ Data

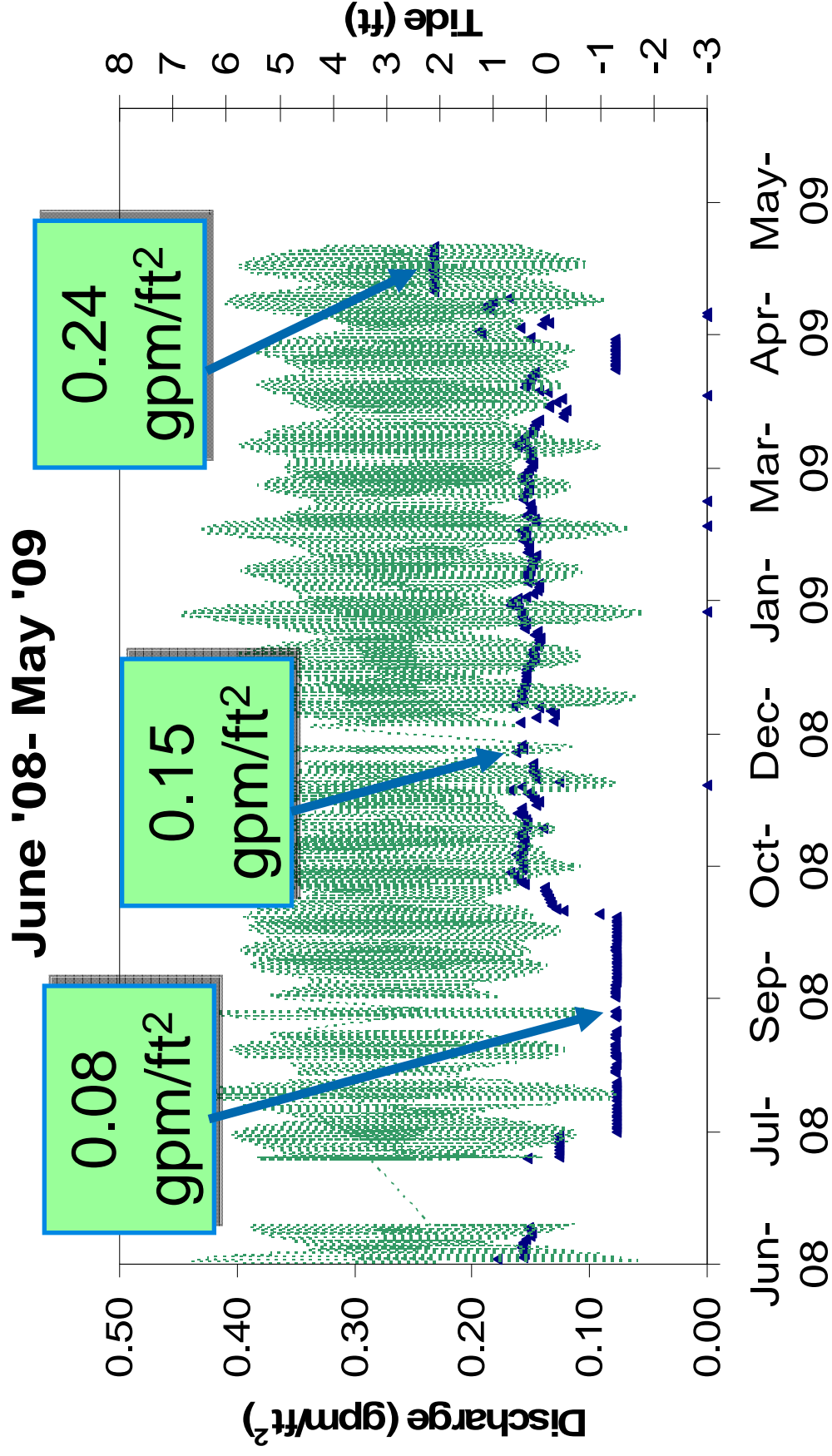
Parameter	Units	Demo Raw	Microfilter Raw Water	Microfilter Effluent
pH	----	7.6	7.9	
Conductivity	µmho/cm	49,600	51,280	51,044
TDS	mg/L	35,180	36,450	36,546
TSS	mg/L	47	52.5	43.75
UV ₂₅₄	1/cm	0.025	0.052	0.027
TOC	mg/L	0.33	0.145	0.2
Turbidity	NTU	2.58	2.14	0.15
SDI ₁₅	----	6.67	6.67	0.77



System Infiltration

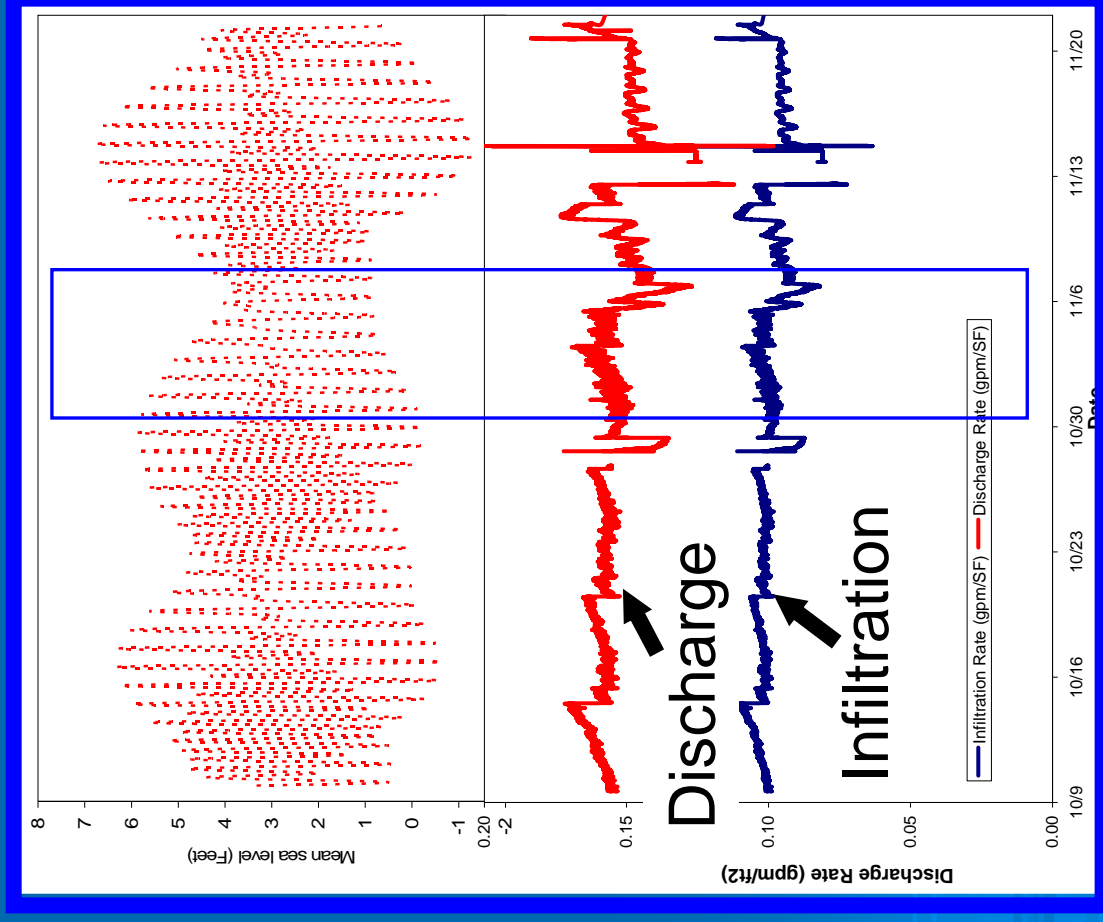


System Discharge

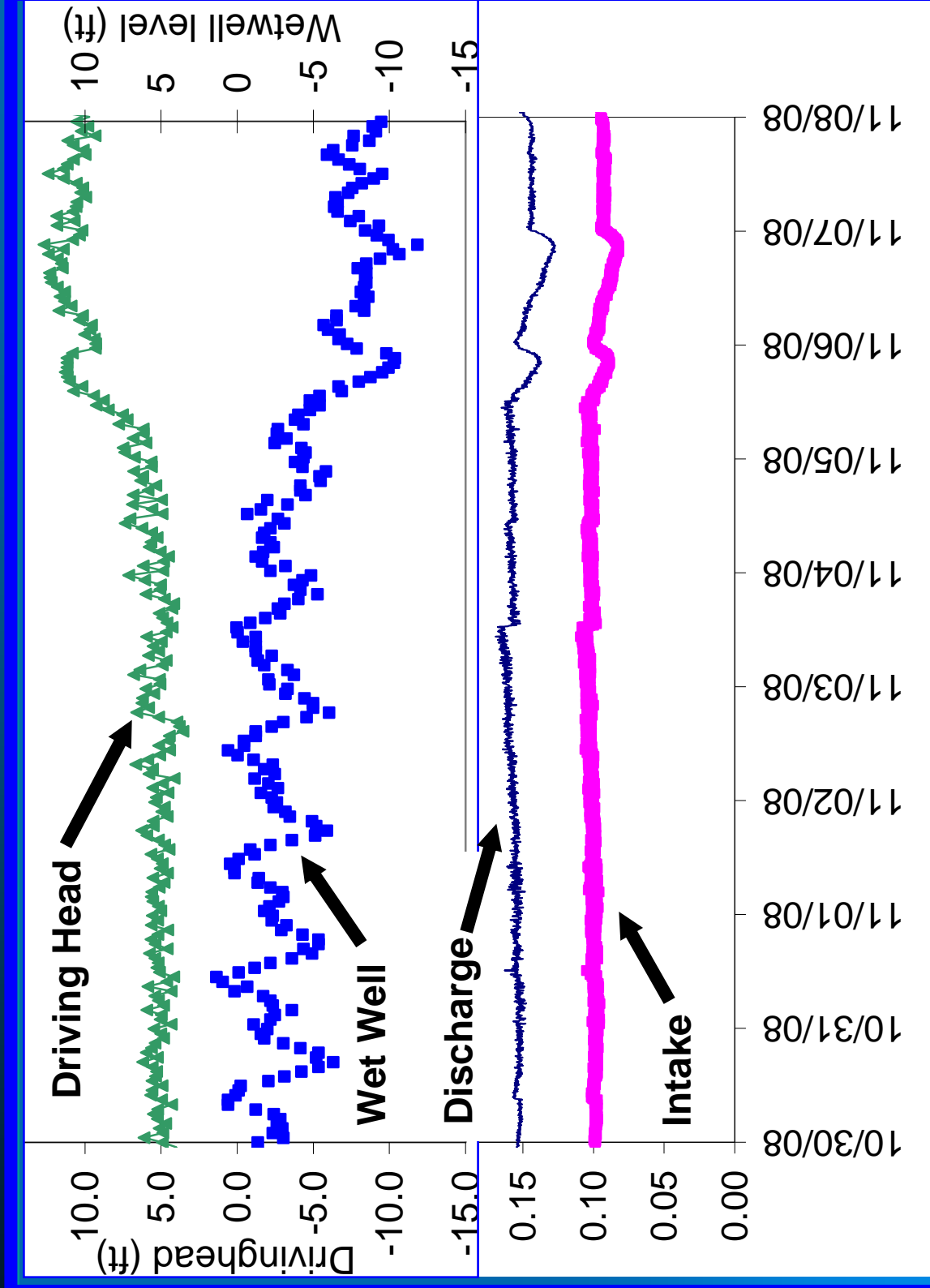


Infiltration/Discharge Yield

No Impact
From Tidal
Conditions



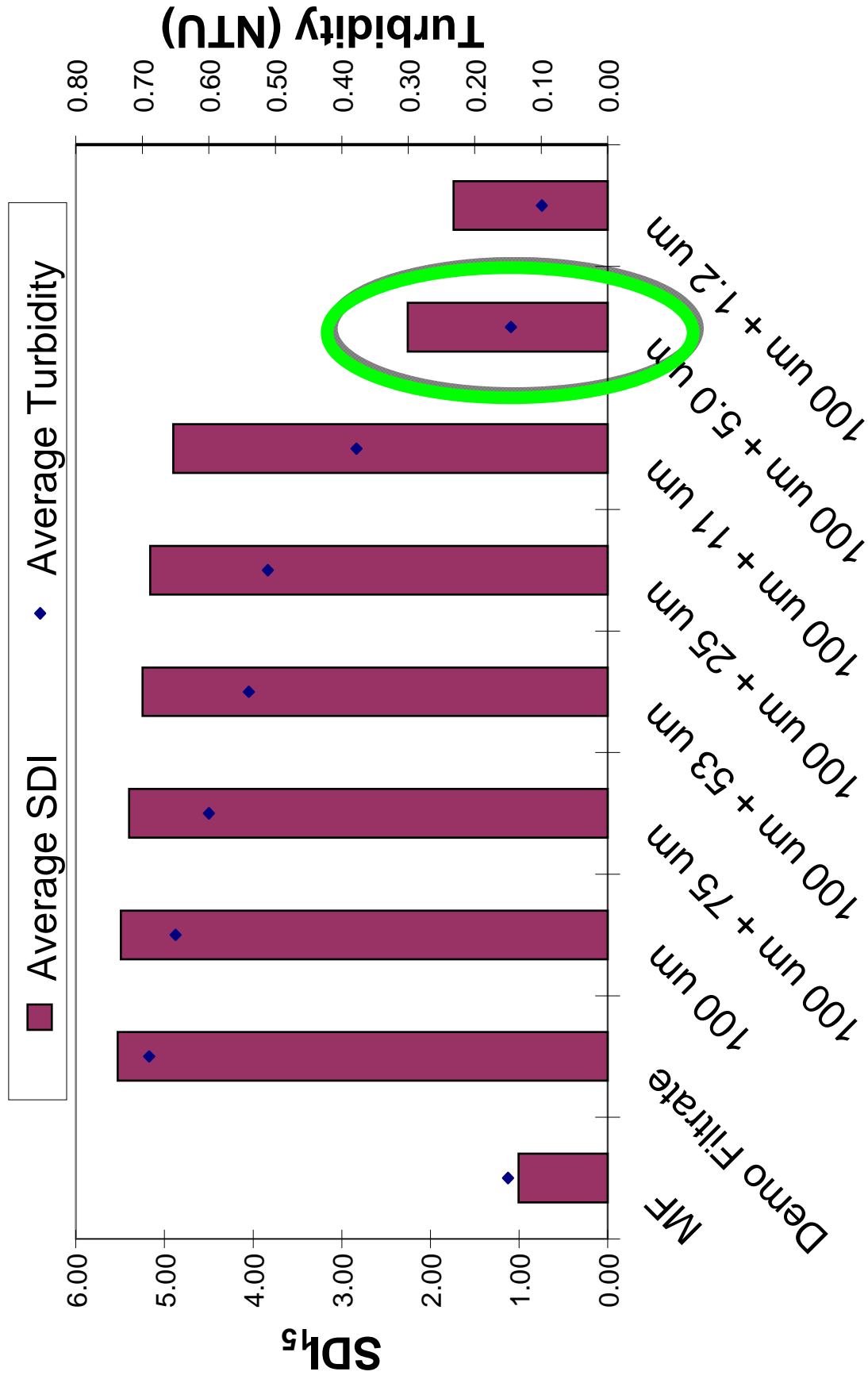
Tidal Influence



Demonstration Testing

- The infiltration yield of the system appears to be working, but what about water quality??
- Microfiltered water is used as a baseline for comparison
 - ❖ Initial results for the demonstration filter effluent did not meet the desired quality
 - Bench-scale tests conducted to simulate in-line cartridge filtration (CF) Pore size-100, 75, 53, 11, 5 and 1.2 μm

Turbidity and SDI

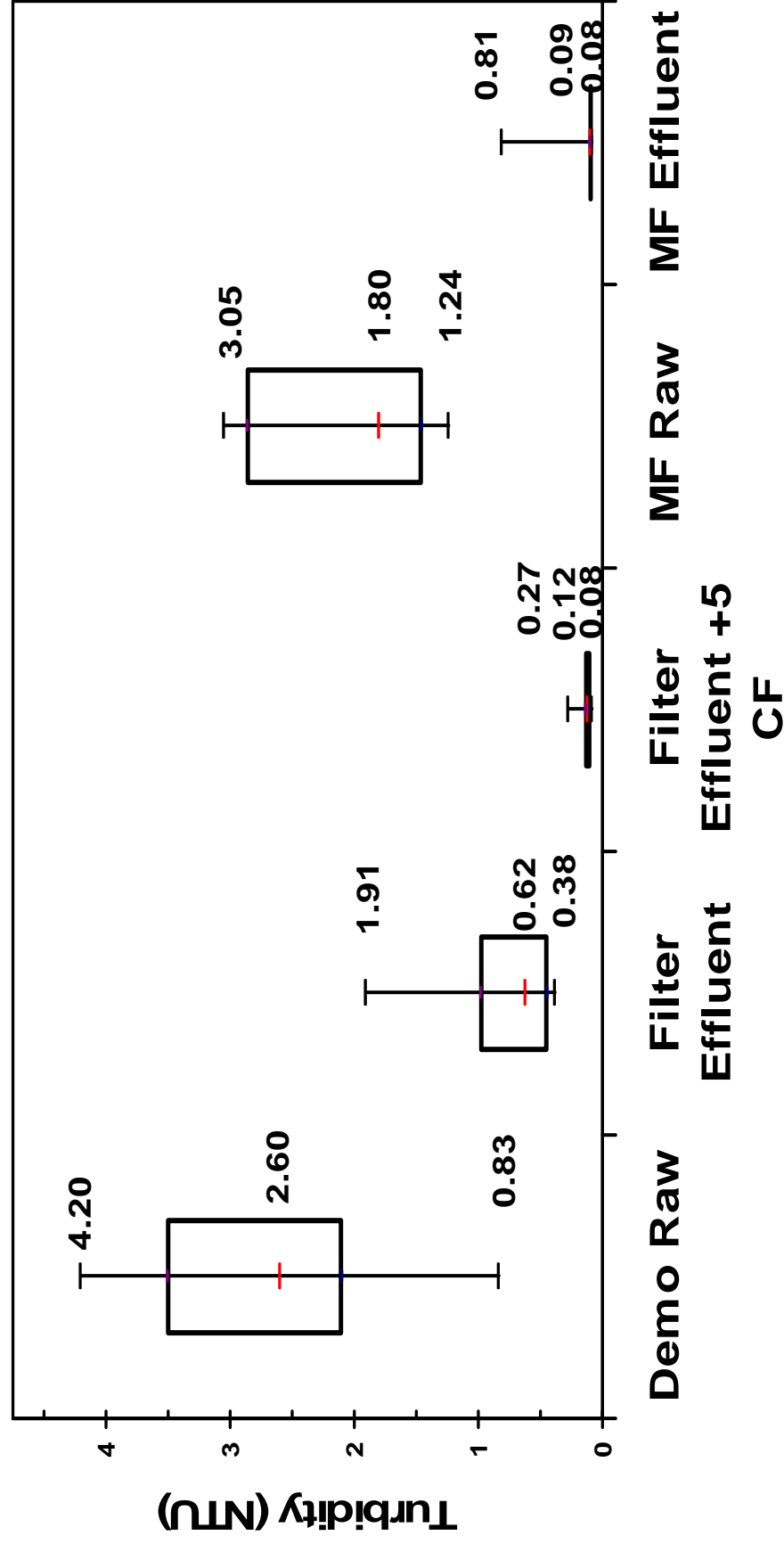


Cartridge Filtration



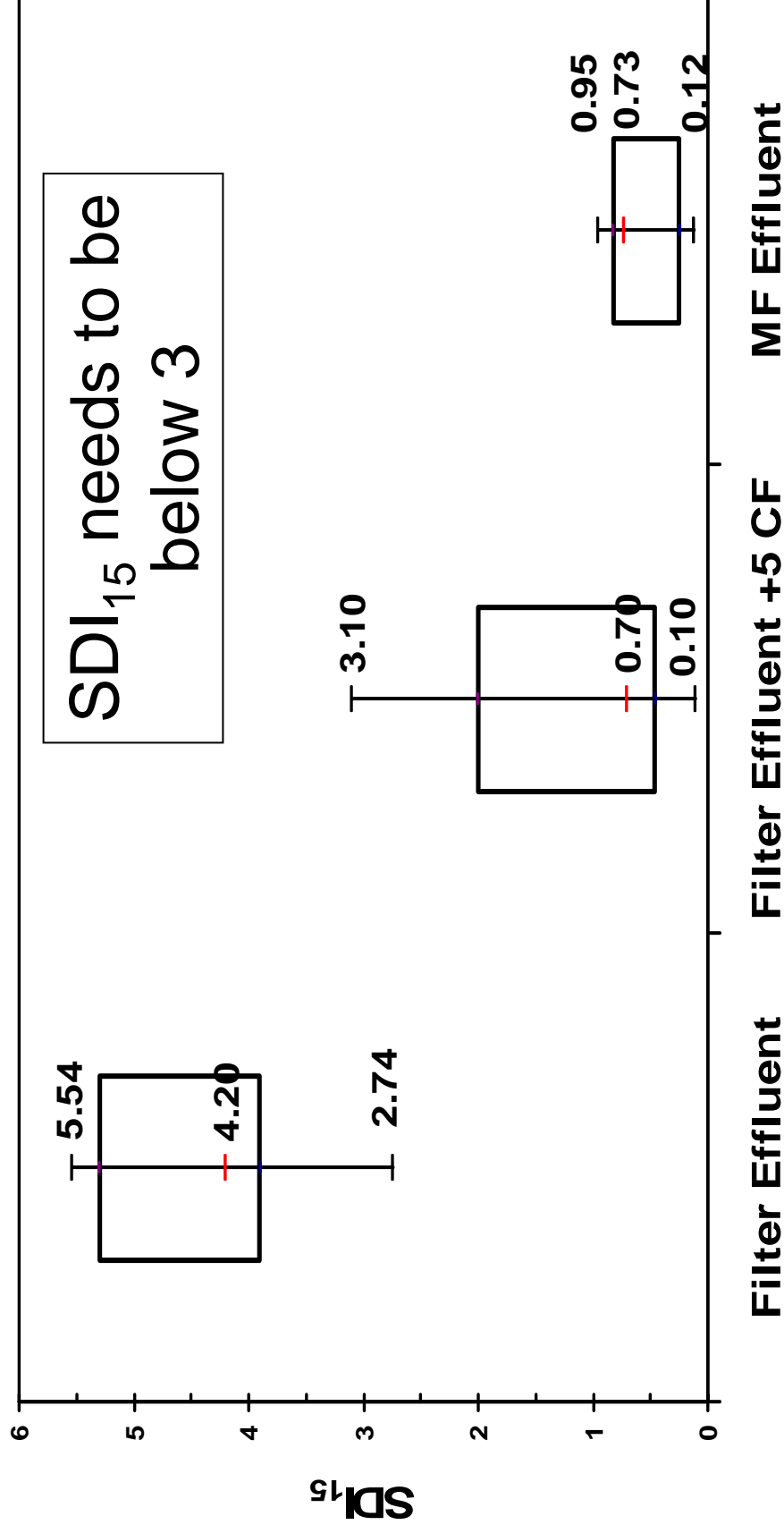
Turbidity (0.1 gpm/ft²)

Turbidity Comparision



SDI₁₅ (0.1 gpm/ft²)

SDI₁₅ Comparison

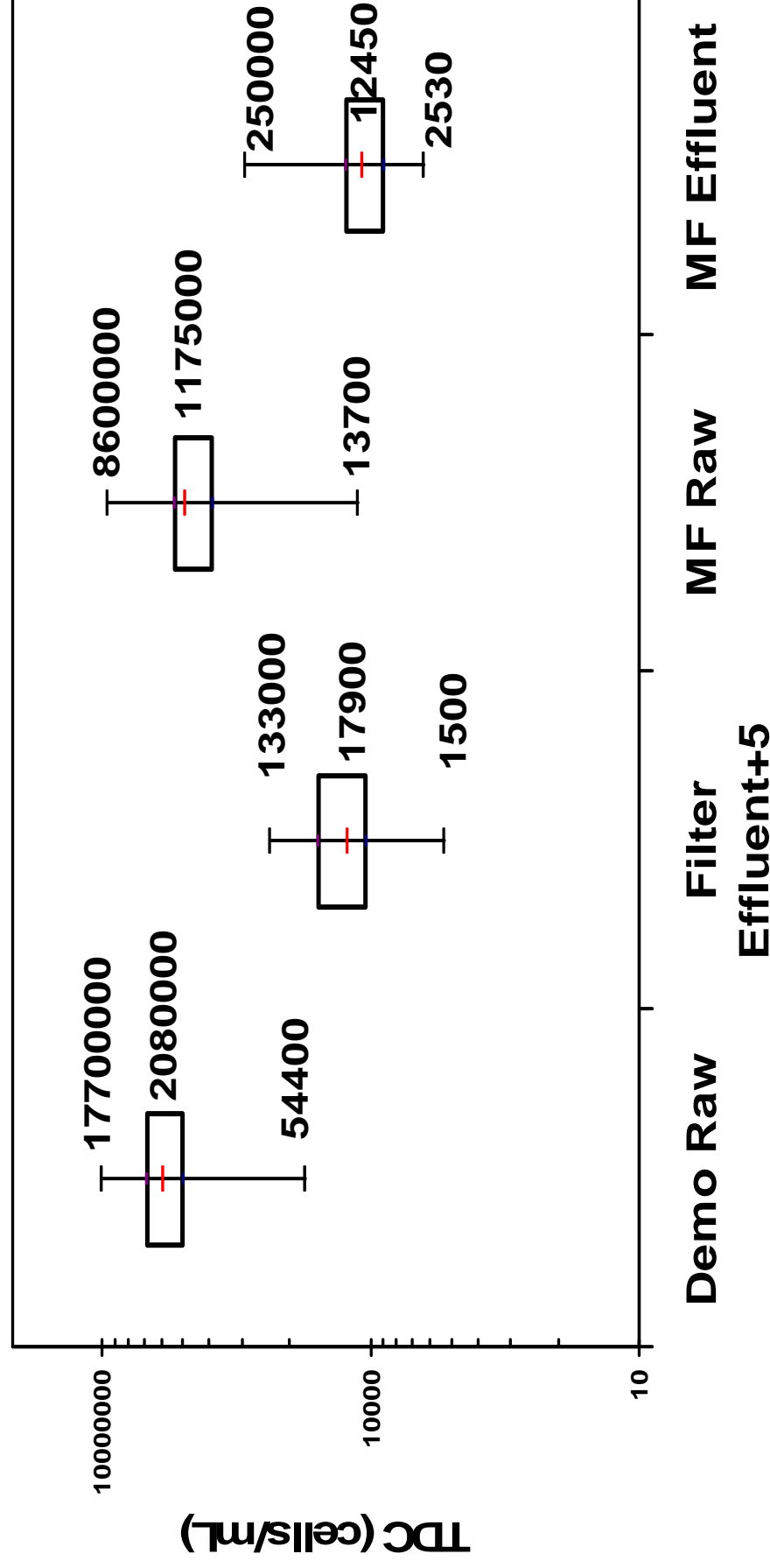


Demonstration Testing

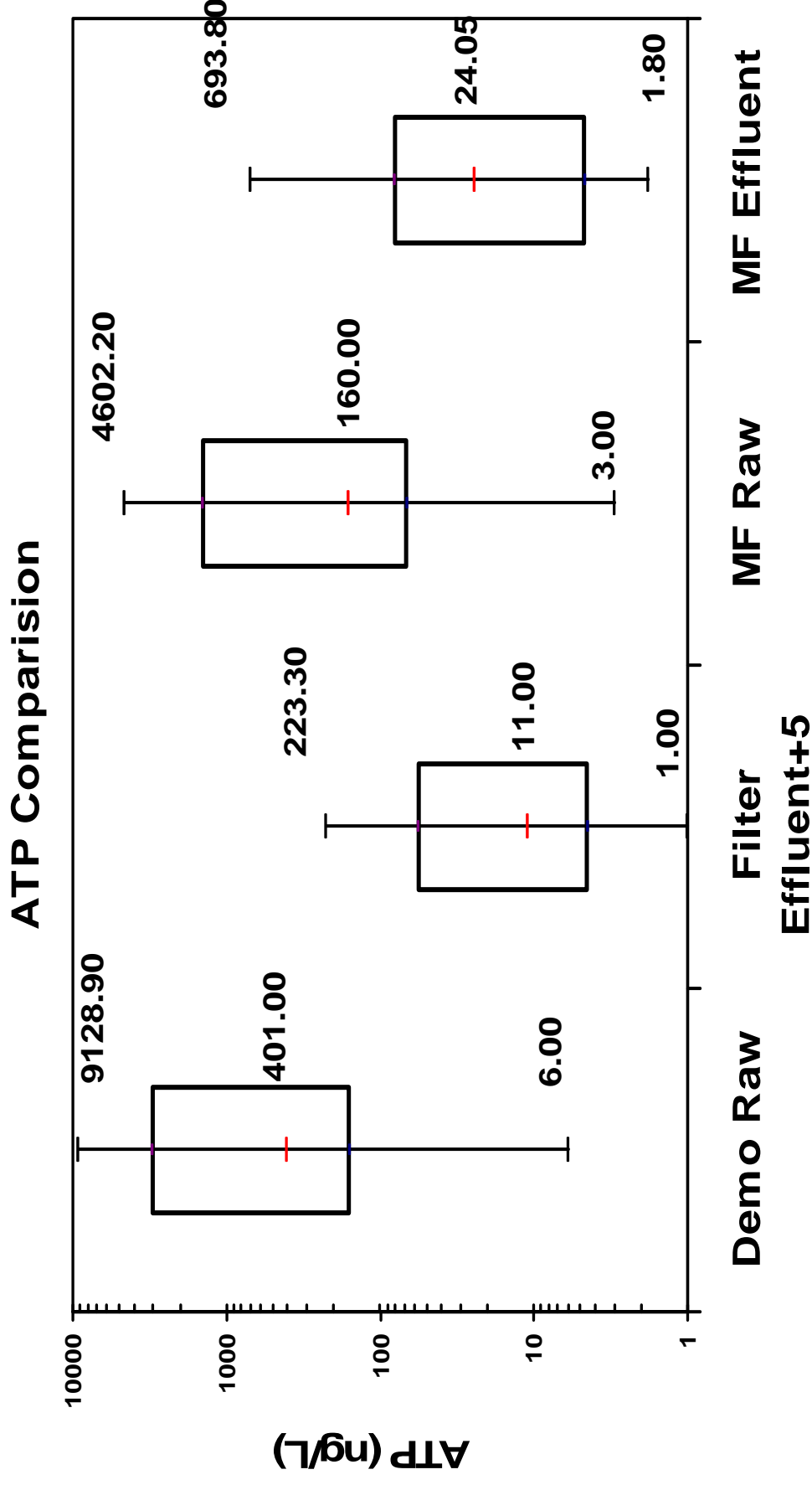
- Qualitative perspective on effects from microorganisms and biological activity as a potential for membrane fouling
 - ❖ Biological activity indicators include total direct counts (TDC), and Adenosinetriphosphate (ATP).
 - ❖ Growth promoting compounds include dissolved organic carbon (DOC), and assimilable organic carbon (AOC)

TDC Analysis

TDC Comparision

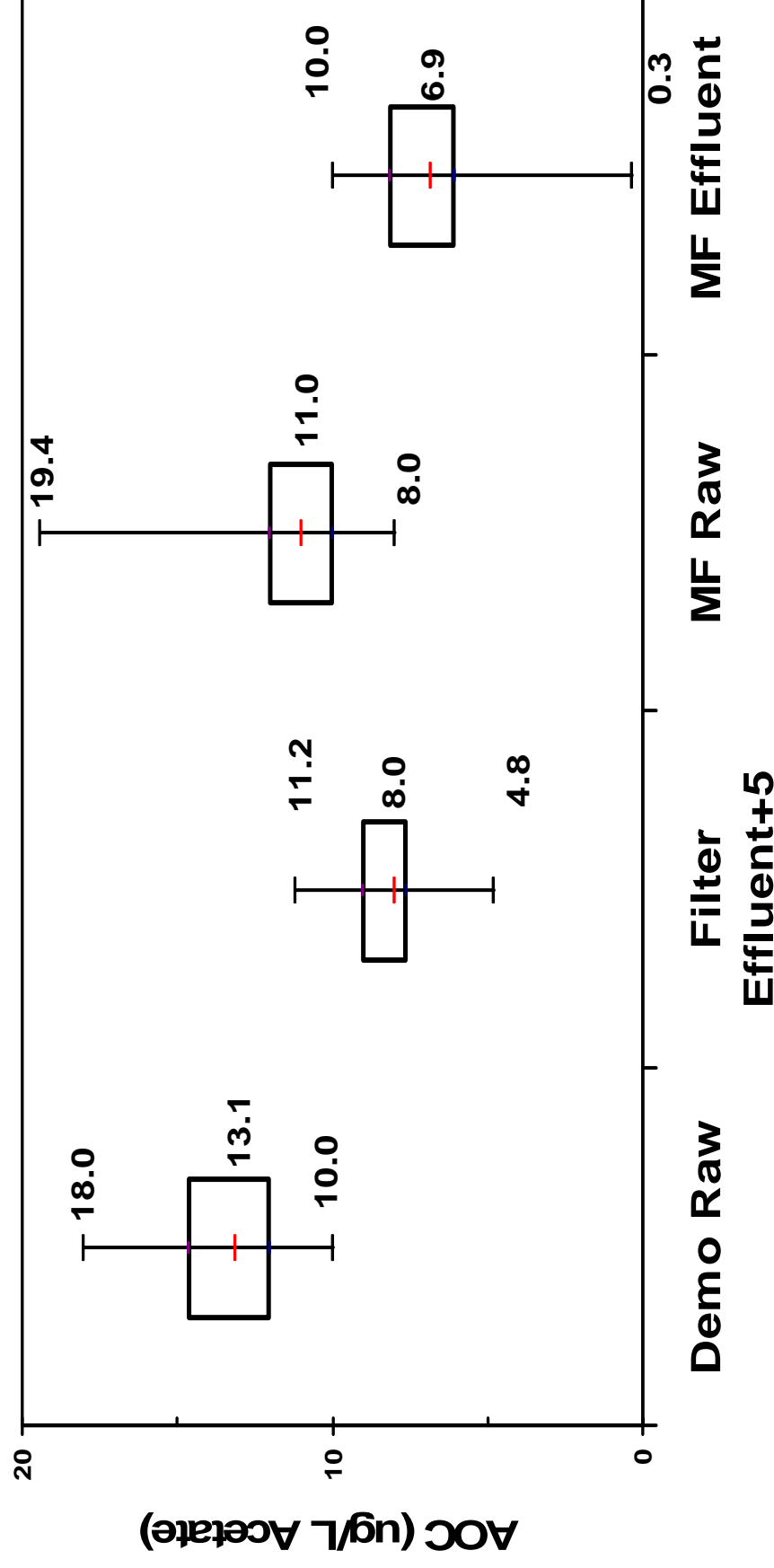


ATP Analysis



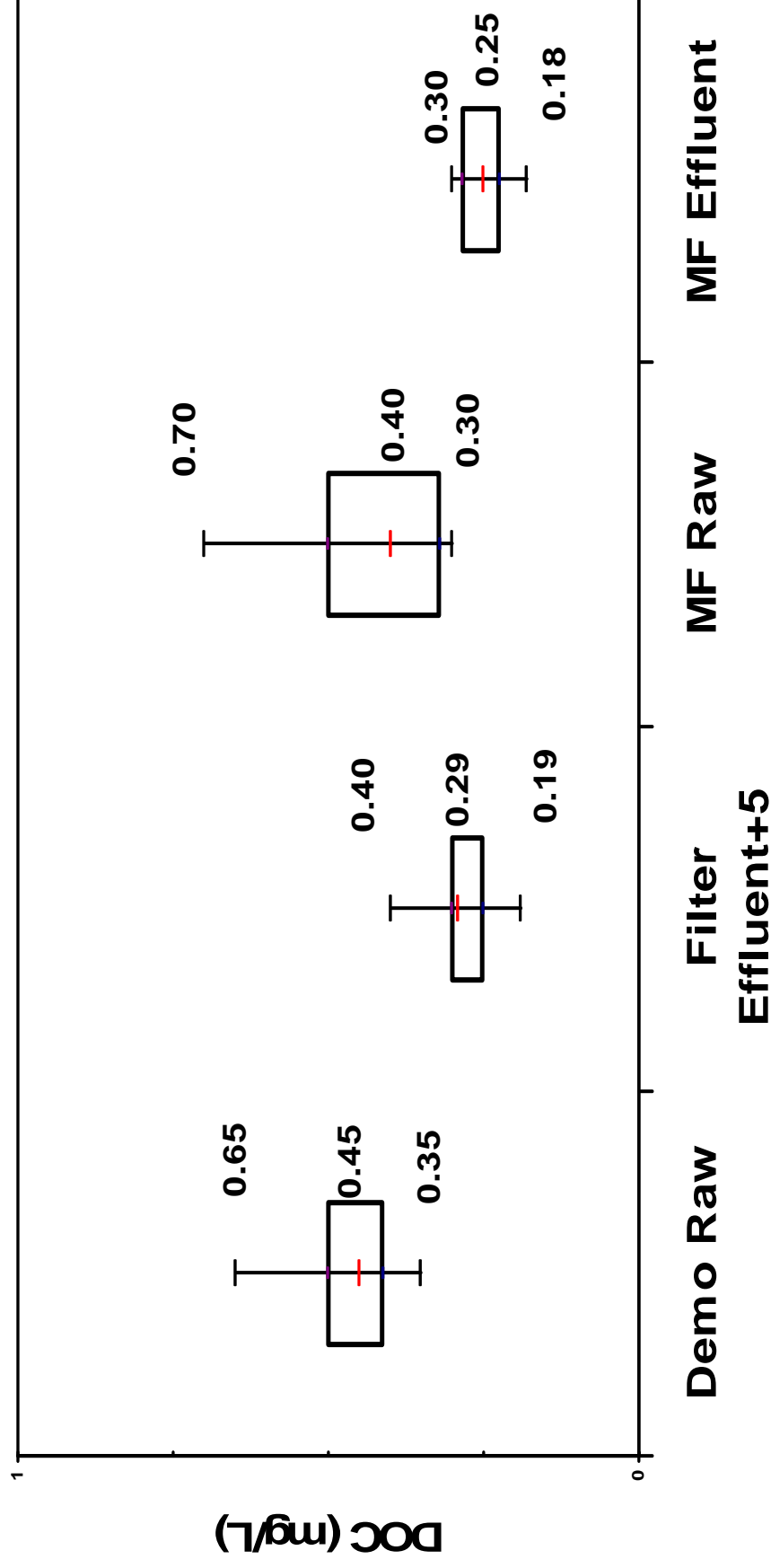
AOC Analysis

AOC Comparision



DOC Analysis

DOC Comparision



Conclusions

Initial data analysis of system flows shows that the lower filtration rate of 0.05 gpm/ft² and the intermediate filtration rate of 0.1 gpm/ft² show no significant tidal influence on production.

Conclusions

The secondary goal of water quality-cartridge filtration system of 100 μm and 5 μm filters improves the turbidity and SDI effluent to a comparable level as the MF effluent

Discharge from system is showing no impacts from Tide conditions or plugging

Next Steps...

- ➔ Further evaluations of the tide and flow at higher infiltration & discharge rates (0.15 & 0.25 gpm/ft²) will be conducted to ensure flows can be sustained
- ➔ Work will be conducted on actual desalting membranes to evaluate the biological fouling potential of the water

Special Thanks

- Long Beach Water Department's staff, Cynthia Andrews-Tate, Ana Flores, and Eric Mintz for conducting the laboratory work
- CA Department of Water Resources and the US Bureau of Reclamation for partial funding of this project
- Technical Reviewers Dr. Steve Duranceau, Steven Hubbs, and Dr. Gary Logsdon

Thank You

Questions

<http://lbwd-desal.org/>